











Guidelines to Evaluate the Usability and User Experience of Learning Support Platforms: A Systematic Review

Juan Salas¹ , Alberto Chang¹ , Lourdes Montalvo¹ ,
Almendra Núñez¹ , Max Vilcapoma¹ , Arturo Moquillaza^{1,2} ,
Braulio Murillo¹ , and Freddy Paz¹ 

¹ Pontificia Universidad Católica del Perú, San Miguel, Lima 32, Peru
{juan.salas, montalvo.lourdes, bmurillov}@pucp.edu.pe,
{alberto.chang1, almendra.nunezc, christian.vilcapomag,
amoquillaza, fpaz}@pucp.pe

² Universidad San Ignacio de Loyola, La Molina, Lima 12, Peru
miguel.moquillaza@usil.pe

Abstract. Nowadays, the usability and the user experience, are important aspects for the success of any software product. In the educational domain, Learning Support Platforms are not the exception, and these quality attributes become essential to guarantee an appropriate teaching process. For this reason, in this study, we present a systematic literature review whose purpose was to identify the characteristics that these types of systems must meet to obtain usable products. In the same way, the features that contribute to the assurance of a satisfying user experience have been cataloged. The purpose of this study is to establish the basis towards the elaboration of a future framework to quantify the level of usability and user experience of learning support platforms. The systematic search retrieved a total of 105 studies, from which 23 were selected as relevant. A set of 15 sub-attributes with their corresponding guidelines were identified to serve as a guide to design graphical user interfaces in a correct way in this type of software systems.

Keywords: Human-Computer Interaction · Systematic review · Usability evaluation · User experience · Guidelines and principles · Education

1 Introduction

Over the years, technology has been evolving on a large scale, which has led many organizations to take advantage of this event and make efforts to implement learning management systems (LMS), which improves the quality and scope of learning processes [1]. The Education sector is one of the most interesting sectors to analyze regarding the use of this type of LMS tools [2]. In order for the LMS to fulfill its objective efficiently, certain aspects must be considered, such as motivation, interest, commitment, focus on the task, behavior and much more [3].

Sometimes, the efficiency of the LMS is affected by the lack of usability. This is because the user could invest more effort in trying to understand the software than in

carrying out their activities. Therefore, there are two factors that must be considered for the success of the LMS: the quality of information and the way in which it is displayed to the user. According to Westfall, it was reported that 61% of people surveyed affirm that one of the inconveniences they had with LMS was learning how it works [4].

Therefore, usability is one of the key factors for the user to achieve satisfaction while using the LMS. This involves making the software easy to use and learn, with a user-friendly interface; displaying the content of a simple and orderly manner, thus preventing the user to focus on these issues [5]. Measuring usability is considered one of the great challenges, this is because there is no standard model which covers all the necessary usability attributes [6].

Heuristic evaluation is one of the most commonly used qualitative techniques to inspect software interfaces and find problems that affect usability [7]. On the other hand, quantitatively assessing the level of usability provides certain benefits, such as making objective comparisons between the software of the same type, which makes it easier for companies to make decisions to choose the best product [8]. With a numerical score, it favors the identification of the state of the level of usability of the software [9].

In this research, it is proposed to find those most important features about usability and electronic learning, as well as quantitative usability evaluations, taking into account heuristics and guidelines. To achieve this, a systematic literature review was carried out, following the Kitchenham methodology. Thus, the most important research on the subject was identified, which will serve as support to build a preliminary framework that allows quantifying the level of usability in those support tools for learning, in the near future.

2 A Systematic Literature Review

To identify those important key aspects that LMS must meet, a systematic review was conducted. The purpose of identifying those aspects was to analyze them, systematize them, and to propose in a future research, a framework to assess the usability and user experience based on the most important identified aspects.

The present systematic review was performed based on the parameters defined by Kitchenham and Charters [10]. In this case, the activities that were performed are: (1) definition of the research questions and search strategy, (2) selection of the primary studies, the extraction of the papers and (3) analysis of the results.

2.1 Research Questions

The main objective was to summarize some studies related to usability, user experience, learning management systems and usability evaluation methods. We used the PICOC table criteria in order to do this review according to the protocol established by Petticrew and Roberts [11]. In addition, we employed synonyms and related terms to find better results. These criteria are shown in Table 1.

Table 1. General concepts defined using the PICOC criteria.

Criterion	Description
Population	Web platforms that support learning
Intervention	Heuristic evaluation of usability and user experience
Comparison	Other methods of usability evaluation
Outcome	Case studies in which any method of usability evaluation is applied
Context	Academic and business context, including all types of stakeholders and empirical studies

Based on the concepts established using PICOC, we defined the following research questions oriented to identify relevant aspects in the design of graphical interfaces for learning management systems:

- **RQ1:** Which are the most relevant aspects of usability and user experience?
- **RQ2:** Which are the most important characteristics in LMS?
- **RQ3:** Which are the activities/characteristics of the usability evaluation models?
- **RQ4:** Which are the guidelines considered in other domains to evaluate usability?

2.2 Search Strategy

We defined our search strategy based on the general concepts. Some synonymous were selected to achieve a more comprehensive search. The search process was performed by using four recognized databases to search for primary studies: ACM Digital Library, IEEEExplore, SCOPUS and SpringerLink. Grey literature was excluded since it is not peer reviewed.

In this phase, the search chains or queries that were used in the search engines of each database were formulated. It is important to mention that the syntax of the queries could vary according to the database that is employed. After grouping a series of concepts using the connectors AND/OR, the resulting search string was the following:

(“usability” OR “user experience” OR “UX” OR “HCI”) AND (“heuristic” OR “heuristic evaluation” OR “usability evaluation” OR “model evaluation usability”) AND (“quantify” OR “quantitative” OR “approach quantitative” OR “comparative” OR “comparative analysis” OR “methodology to evaluate usability” OR “quantify usability” OR “measure usability” OR “method to evaluate usability”) AND (“interface” OR “software” OR “web” OR “system” OR “satisfaction” OR “characteristic” OR “guideline” OR “design” OR “methodology” OR “case study”) AND (“elearning” OR “e-learning” OR “learning management system” OR “LMS” OR “education” OR “higher education” OR “university” OR “e-learning system” OR “web platform to teaching” OR “web platform” OR “web system to support teaching”).

2.3 Search Process and Data Extraction

In order to determine if an article must be considered as relevant, we defined the following inclusion criteria: *the study should present a methodology, framework or*

study case in which the usability and user experience are evaluated. In the same way, we defined the exclusion criteria: *in the study, the specialists do not apply a usability or user experience evaluation in an intangible product as a software.* The automated search for our systematic mapping review was performed on October 20th, 2018. Table 2 shows the search results that were found. In addition, Table 3 shows the selected studies from the four databases used in this research. These studies were selected by discarding the studies that do not meet the inclusion criteria and present any of the exclusion criteria.

Table 2. Search results for RQ1, RQ2, RQ3 and RQ4.

Database name	Search results	Duplicate papers	Relevant papers
ACM Digital Library	24	–	9
IEEEExplore	13	–	6
Scopus	36	4	7
SpringerLink	32	2	1
TOTAL	105	6	23

Table 3. Selected primary studies.

Study id	Author name	Year	Title
SS1 [12]	Hedegaard and Simonsen	2013	Extracting usability and user experience information from online user reviews
SS2 [13]	Al-Farries et al.	2013	Evaluating the accessibility and usability of top Saudi e-government services
SS3 [14]	Dias et al.	2014	HEUA: A heuristic evaluation with usability and accessibility requirements to assess Web systems
SS4 [6]	Hasan and Al-Sarayreh	2015	An integrated measurement model for evaluating usability attributes
SS5 [15]	Hovde	2015	Effective user experience in online technical communication courses: employing multiple methods within organizational contexts to assess usability
SS6 [16]	Choma et al.	2016	Working beyond technical aspects: an approach for driving the usability inspection adding the perspective of user experience
SS7 [17]	Quiñones et al.	2017	A methodology to develop usability/user experience heuristics
SS8 [18]	Sagar and Saha	2017	Qualitative usability feature selection with ranking: a novel approach for ranking the identified usability problematic attributes for academic websites using data mining techniques

(continued)

Table 3. (continued)

Study id	Author name	Year	Title
SS9 [19]	Hasan	2018	Usability problems on desktop and mobile interfaces of the Moodle Learning Management System (LMS)
SS10 [20]	AlRoobaea et al.	2013	A framework for generating a domain specific inspection evaluation method: A comparative study on social networking websites
SS11 [21]	Gordillo et al.	2014	The usefulness of usability and user experience evaluation methods on an e-Learning platform development from a developer's perspective: A case study
SS12 [22]	Iman and Rasoolzadegan	2015	Quantitative evaluation of software usability with a fuzzy expert system
SS13 [23]	Mtebe and Kissaka	2015	Heuristics for evaluating usability of Learning Management Systems in Africa
SS14 [24]	Kabir et al.	2016	An analytical and comparative study of software usability quality factors
SS15 [9]	Granollers	2016	Validación experimental de un conjunto heurístico para evaluaciones de UX de sitios web de comercio-e
SS16 [25]	Ivanović et al.	2013	Usability and privacy aspects of Moodle: Students' and teachers' perspective
SS17 [26]	Sabri et al.	2013	A quantitative approach in the usability evaluation of a courseware
SS18 [27]	Deraniyagala et al.	2015	Usability study of the EduMod eLearning Program for contouring nodal stations of the head and neck
SS19 [28]	Junus et al.	2015	Usability evaluation of the student centered e-Learning environment
SS20 [29]	Murillo et al.	2017	Usability testing as a complement of heuristic evaluation: A case study
SS21 [30]	Emang et al.	2017	Usability studies on E-Learning Platforms: Preliminary study in USM
SS22 [8]	Paz et al.	2018	Quantifying the usability through a variant of the traditional heuristic evaluation process
SS23 [31]	Aparna and Baseer	2015	SIRIUS-WUEP: A heuristic-based framework for measuring and evaluating Web usability in model-driven Web development

In addition, some secondary studies were identified applying the inclusion and exclusion criteria to the references established in the most relevant of the primary studies. These secondary papers are shown in Table 4.

Table 4. Selected secondary studies.

Study ID	Author name	Year	Title
SS24 [32]	Eason	1984	Towards the experimental study of usability
SS25 [33]	Nielsen	1993	Usability engineering
SS26 [34]	ISO 9241-11	1998	Ergonomics requirements for office work with visual display terminals (VDTs) – Part 11: Guidance on usability
SS27 [35]	ISO 9126-1	2001	Software engineering – Product quality
SS28 [36]	Reeves et al.	2002	Usability and instructional design heuristics for e-learning evaluation
SS29 [37]	Folmer et al.	2003	A framework for capturing the relationship between usability and software architecture
SS30 [38]	Abran et al.	2003	Usability meanings and interpretations in ISO standards
SS31 [39]	Rosato et al.	2004	Usability of course management systems by students
SS32 [40]	Mehlenbacher et al.	2005	Usable E-Learning: A conceptual model for evaluation and design
SS33 [41]	Dringus and Cohen	2005	An adaptable usability heuristic checklist for online courses
SS34 [42]	Ardito et al.	2005	An approach to usability evaluation of e-learning applications
SS35 [43]	Seffah et al.	2006	Usability measurement and metrics: A consolidated model
SS36 [44]	Nielsen and Loranger	2006	Prioritizing Web Usability
SS37 [45]	Bevan	2008	Classifying and selecting UX and usability measures
SS38 [46]	Ketola and Roto	2008	Exploring user experience measurement needs
SS39 [47]	Zaharias and Poylymenakou	2009	Developing a usability evaluation method for e-learning applications: Beyond functional usability
SS40 [48]	Giannakos	2009	A combinational evaluation method of computer applications
SS41 [49]	Al-Khalifa	2010	Heuristic evaluation of the usability of E-Government Websites: A case from Saudi Arabia
SS42 [50]	Al-Sarrayih et al.	2010	Evaluation of a Moodle based learning management system applied at Berlin institute of technology based on ISO-9126
SS43 [51]	Giannakos	2010	The evaluation of an e-learning web-based platform
SS44 [52]	ISO 25010	2011	Systems and software engineering – Systems and software Quality Requirements and Evaluation (SQuaRE) – System and software quality models

(continued)

Table 4. (continued)

Study ID	Author name	Year	Title
SS45 [53]	Zaharias	2011	Heuristic evaluation of e-learning courses: a comparative analysis of two e-learning heuristic sets
SS46 [54]	Ghirardini	2011	E-learning methodologies. A guide for designing and developing e-learning courses
SS47 [55]	Kumar Dubey et al.	2012	Usability evaluation of object-oriented software system using fuzzy logic approach
SS48 [56]	Torrente et al.	2013	Sirius: A heuristic-based framework for measuring web usability adapted to the type of website
SS49 [57]	Şenol et al.	2014	Usability evaluation of a Moodle based learning management system
SS50 [58]	Thuseethan et al.	2014	Usability evaluation of learning management systems in Sri Lankan universities
SS51 [59]	Gupta and Ahlawat	2014	A critical analysis of a hierarchy-based usability model
SS52 [60]	Paz et al.	2015	Heuristic evaluation as a complement to usability testing: A case study in Web domain
SS53 [61]	Issa and Isaias	2015	Sustainable design: HCI, usability and environmental concerns
SS54 [62]	Rogers et al.	2015	Interaction Design - Beyond Human-Computer Interaction
SS55 [63]	Farmanesh and Samani	2015	Heuristic evaluation of the usability of LMS (Moodle) at EMU

Once these studies were obtained through the secondary review process, these were cataloged based on the relevant works. This information is shown in Table 5.

Table 5. Mapping of primary studies with secondary studies.

Primary study ID	Secondary study ID
SS1	SS25, SS26, SS29, SS35, SS37, SS38
SS2	SS41
SS3	SS25
SS4	SS25, SS26, SS30, SS35, SS37, SS44, SS47, SS51, SS54
SS5	SS32
SS6	SS24, SS36, SS53
SS7	SS26
SS8	SS25, SS47

(continued)

Table 5. (continued)

Primary study ID	Secondary study ID
SS9	SS31, SS42, SS46, SS49, SS50
SS10	SS25, SS26, SS39
SS11	SS26, SS34, SS40, SS43
SS12	SS25
SS13	SS25, SS28, SS33, SS34, SS39, SS45
SS14	SS27, SS35
SS15	–
SS16	–
SS17	–
SS18	SS34, SS39
SS19	SS39
SS20	SS52
SS21	SS25, SS40, SS55
SS22	SS25, SS27
SS22	SS25, SS27

3 Results of the Review

3.1 Relevant Aspects of Usability and User Experience

There were 18 papers that answer RQ1 (SS1, SS4, SS6, SS14, SS24, SS26, SS27, SS29, SS30, SS35, SS36, SS37, SS38, SS44, SS47, SS51, SS53, SS54). The usability/UX aspects that found in the systematic review are shown in Table 6.

Table 6. Usability and UX Aspects found by the Systematic Review Process (RQ1).

Aspect	Study id
Efficiency	SS4, SS14, SS26, SS29, SS30, SS35, SS36, SS47, SS51, SS53, SS54
Learnability	SS1, SS4, SS14, SS27, SS29, SS30, SS35, SS36, SS37, SS44, SS54
Satisfaction	SS1, SS4, SS14, SS26, SS29, SS30, SS35, SS36, SS47, SS51, SS53
Effectiveness	SS4, SS14, SS26, SS30, SS35, SS37, SS47, SS51, SS53
Accessibility	SS4, SS35, SS37, SS44
Memorability	P36, SS51, SS54
Protection	SS35, SS37, SS54

(continued)

Table 6. (continued)

Aspect	Study id
Universality	SS4, SS35, SS51
Esthetic	SS1, SS4, SS44
Operability	SS4, SS14, SS27
Errors	SS1, SS36
Hedonic	SS1, SS38
Recognizable	SS4, SS44
Security	SS30, SS51
Attractiveness	SS14, SS27
Reliability	SS14, SS29
Usability Compliance	SS14, SS27
Utility	SS35, SS54
Functionality	SS53
Impact	SS38
General Usability	SS38
Special Users	SS53
Specific Context of Use	SS53
Support	SS38
Trustfulness	SS35
Anticipation	SS38
User Difference	SS38
Protection against user errors	SS44
Aesthetics of user interface	SS44
Others	SS1, SS14, SS24, SS27, SS38, SS53

3.2 Important Characteristics in Learning Management Systems

In the same way, to answer RQ2, 14 papers were selected (SS5, SS9, SS13, SS16, SS19, SS21, SS28, SS31, SS32, SS39, SS42, SS46, SS49, SS50). According to the authors, there are relevant design aspects that contribute to satisfy the learning objectives that are frequently requested by the educational institutions when they search for learning tools. We detail some of those design aspects in Table 7.

Table 7. LMS Characteristics found by the Systematic Review Process (RQ2).

Study id	Characteristic
SS9	<ul style="list-style-type: none"> - <i>Consistency in the interface language</i> - <i>Aesthetic design of the pages</i> - <i>Appropriate content for each system page</i> - <i>Consistent information</i>
SS13	<ul style="list-style-type: none"> - <i>Instructional materials</i> - <i>Collaborative learning</i> - <i>Learning control</i> - <i>Feedback and evaluations</i> - <i>Accessibility</i> - <i>Motivation to learn</i>
SS16	<ul style="list-style-type: none"> - <i>General quality of existing teaching material</i> - <i>Tests</i> - <i>Collaborative assignments</i> - <i>Use of communication tools (forums, wikis, chats)</i> - <i>Express opinions (surveys)</i> - <i>Privacy concerns</i> - <i>Technical problems and localization (language)</i>
SS19	<ul style="list-style-type: none"> - <i>Content: factor consisting of the languages and terms used, support and learning materials, and other information in the system.</i> - <i>Learning and support: it is related to the characteristics of the platform for sending materials, discussions, evaluations, etc.</i> - <i>Visual design</i> - <i>Accessibility</i> - <i>Interactivity: factor related to all forms of communication in the context of learning that is facilitated by the system</i> - <i>Auto evaluation and system learning</i> - <i>Motivation to learn</i>

3.3 Activities and Characteristics of the Usability Evaluation Models

There were 11 papers that answer RQ3 (SS3, SS12, SS15, SS17, SS20, SS22, SS23, SS28, SS32, SS45, SS52). Some important strategies related to the process that must be followed in a usability/UX evaluation were obtained from these studies. These approaches were compared to decide how to establish the assessment framework. We show some of those strategies in Table 8.

Table 8. Characteristics/Activities of Usability Evaluations found by the Systematic Review Process (RQ3).

Study id	Characteristic
SS3	<i>This study proposes a questionnaire that evaluates usability and accessibility in support platforms for learning quantitatively</i> - Evaluate the usability and accessibility of websites - It is composed of 93 requirements, which have been classified based on 10 Nielsen heuristics
SS15	- It is oriented to the application of electronic commerce systems - It is divided into 6 aspects - It consists of 64 guidelines that will be in charge of being evaluated for the qualification of the system - The objective of this is to obtain a degree of usability to determine the state of the system and - in addition - comparisons can be made between them
SS22	- This study presents a variation with respect to the study carried out by Granollers - The 'Yes' answers will have a score of 4, while the 'No' answers will be assigned the value of 0. For those questions that the evaluator feels is not met at all, you can choose a score between 1, 2, 3
SS32	- Group heuristics in 5 dimensions - They are based on activities related to teaching and learning with technology

3.4 Guidelines to Evaluate the Usability Attribute

Finally, the RQ4 is related with the principles used in the heuristic evaluation models which allow to get the usability level - quantitatively or qualitatively - in the platforms from other domains, that can be used as well for learning support platforms. There were 18 papers that were used to answer this research question (SS2, SS3, SS7, SS8, SS10, SS11, SS18, SS23, SS25, SS28, SS32, SS33, SS34, SS40, SS41, SS43, SS48, SS55). Some the guidelines found are shown in Table 9.

Table 9. Guidelines to Evaluate Usability found in the Systematic Review Process (RQ4).

Study id	Guidelines (1/2)	Guidelines (2/2)
SS3	- Visibility of the study of the system - Comparability between the framework and the real world and comparability between the designer model and the apprentice model - Control and freedom learners - Consistency and compliance with standards - Help and documentation	- Error prevention of the discard of circumferential errors related to usability - Recognition instead of memory - Flexibility and efficiency of use - Legitimacy and minimalism in the design - Identify recognition and improvement of errors

(continued)

Table 9. (continued)

Study id	Guidelines (1/2)	Guidelines (2/2)
SS8	<ul style="list-style-type: none"> - <i>Organization of contents</i> - <i>Design and design evaluation.</i> - <i>Navigation</i> - <i>Search</i> - <i>Titular, titles and labels.</i> - <i>Scroll and pagination.</i> - <i>Page design</i> - <i>Home page</i> 	<ul style="list-style-type: none"> - <i>Accessibility</i> - <i>Optimizing the user experience</i> - <i>Graphics, images and multimedia</i> - <i>Internationalization</i> - <i>Mobile</i> - <i>Security</i> - <i>Social communication media</i>
SS33	<ul style="list-style-type: none"> - <i>Visibility</i> - <i>Functionality</i> - <i>Esthetic</i> - <i>Feedback and help</i> - <i>Prevention of the error</i> - <i>Memorability</i> - <i>Course management</i> 	<ul style="list-style-type: none"> - <i>Interactivity</i> - <i>Flexibility</i> - <i>Consistency</i> - <i>Efficiency</i> - <i>Reduce the redundancy</i> - <i>Accessibility</i>
SS34	<ul style="list-style-type: none"> - <i>Support for learning/authorship</i> - <i>Support for communication, personalization and access</i> - <i>Adaptation of the structure</i> 	<ul style="list-style-type: none"> - <i>Facilities and technological adaptation</i> - <i>Effectiveness of teaching/authorship</i> - <i>Support efficiency</i>

4 Conclusions and Future Works

The usability and UX have become critical aspects to be considered in the development of software products. Nowadays, these quality attributes represent the main concerns of the software industries, since ensuring a high level of ease of use and UX in the applications, leads to establish an environment of appropriate use for the interaction with the system. The new paradigm in the software development is not only about providing the users with a tool to achieve their goals but also to ensure that the user experience is quality enough to generate satisfaction on the end user.

In this study, we performed a systematic literature review following a recognized and widely used methodology. According to this protocol, we identified 105 studies, from which 23 were selected. Furthermore, we considered 32 secondary studies, that provided more information to 4 research questions. This work allowed to identify the most relevant aspects in both usability as learning. Additionally, this review allowed to find characteristics that help to quantify the level usability and UX and some heuristics/guidelines related to domain of study.

The objective of this systematic literature review was to obtain relevant information from previous research to build a preliminary framework that allows quantifying the level of usability and UX in learning support platforms, through a checklist. Therefore, a deeper analysis should be carried out to generate the results to the objectives for the construction of the framework. Also, some of the results must be complemented and validated by interviews and expert judgment, respectively.

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